Volume 22 December, 1936 *Number 12*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Metal Cutting and the Selection of Cutting Fluids—Part Two

Parking Made Easier by Snow Removal Machinery

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- Texaco Soluble Oil—C

THE TEXAS COMPANY

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Published by

The Texas Company, 135 East 42nd Street, New York City

Vol. XXII — December, 1936 — No. 12

Change of Address: In reporting change of address kindly give both old and new addresses.

Metal Cutting and the Selection of Cutting Fluids — Part Two

SELECTION of cutting fluids must be made with due regard for the nature of the work involved. By many the nature of the chip resulting from a cutting operation is regarded as being the criterion. For example, metals or alloys developing a relatively brittle chip which breaks off readily or tends to disintegrate into dust will oftentimes be adaptable to dry cutting. Cast iron is perhaps the best known metal having these characteristics. It is, therefore, frequently cut dry, except where deep work is to be performed. Aluminums and brasses in turn are also adaptable to dry cutting, yet quite as many operators find it advisable to use some form of light viscosity straight mineral oil. With metals and alloys which tend to develop dust to any extent, it is felt that unless a cutting fluid is directed under suitable volume at the correct angle to effectively wash away the cuttings, there will be the possibility of these accumulating at the cutting tool to cause premature dullness.

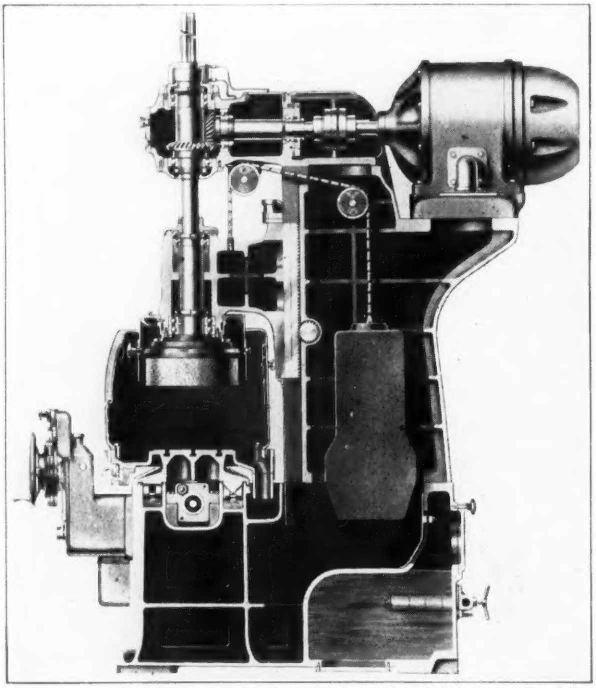
Materials such as high speed tool steels, malleable iron, steel castings and bronzes in turn are regarded as being always subject to better cutting where some cooling and lubricating compound is used. For the softer of these materials, likewise when tapping cast iron, a soluble oil or product with a relatively high water content is generally most satisfactory. Soluble oil has a two-fold advantage in such service, viz., by virtue of its water content it lends itself to more rapid heat transfer, thereby keeping the cutting tool cooler, and it is less sticky than lard, mineral oil or mineral-lard lubricants. There is, therefore, less chance for the tool to burn, especially in the drill, boring mill or milling machine.

The harder materials, however, which develop relatively clean, long chips, are claimed to cut best if a more oily coolant is used, in other words, where the question of lubrication as well as cooling must be considered. Hence the preference of sulfurized mineral-lard oil cutting fluids. When higher speed conditions are involved, especially on deep cutting, the matter of cooling again becomes important. This calls for the use of a soluble oil or cutting compound of high heat-absorbing ability.

The tool operator, therefore, is confronted with a variety of conditions, so dependent upon each other that each individual case will usually require special consideration and research. In fact, where one plant might be able to mill tool steel admirably with a mineral-lard cutting oil, another, doing the same type of work will find it practically essential to use a soluble oil in order to obtain satisfactory results.

Viscosity is an important item in the selection of cutting fluids. Normally, it must never be too low, as applied to mineral oils, otherwise they may be too volatile. Subsequent vaporization as the oil comes in contact with the hot turning tool will cause breakdown, the development of smoke and more or less odor. Furthermore, mineral oils of higher viscosities have

better tool lubricating ability. Since there is a limit to this latter, where definite increase in oiliness is required, it is better to



Courtesy of Pratt & Whitney, Div. Niles-Bement Pond Co.

Fig. 1—Section through a Pratt & Whitney 14 in. hydraulic vertical surface grinder. Coolant is carried in a reservoir outside the bed but cast integrally. It is circulated by a motor-driven pump, and controlled by a suitable valve lever.

use a blend of a fatty oil and a fairly low viscosity mineral oil than to use a straight mineral oil of higher viscosity. On the other hand we must not forget that cooling ability will decrease with increase in viscosity. When the use of a compounded oil is not desirable, the viscosity of the mineral oil should be governed by the cooling requirements.

Since the viscosity is such an important item it is well to outline those disadvantages which may be experienced if it is too high, viz.:

The cooling properties will be decreased by any material increase in viscosity, as the fluidity of the cutting medium governs to a great extent the rate with which the heat developed by the cutting operation can be dissipated.

Oil consumption will be higher when using a more viscous cutting fluid due to the adhesiveness and the tendency to stick to the chips and work; furthermore, a heavy oil will hold small metal chips and dirt in suspension longer than one of lower viscosity. This will tend to lower the life of the cutting tools, and require more time for reclaiming through settling or filtration of the chips.

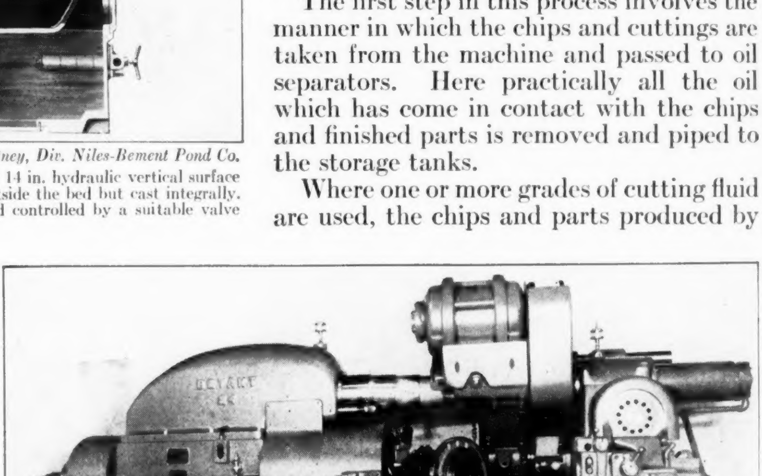
As a result of exhaustive research and practical experience it has been found that the most effective cutting oil should have a viscosity ranging between 100 to 200 seconds at 100 degrees Fahr., Saybolt.

HANDLING OF THE CUTTING OIL

In the handling of cutting fluids storage, distribution and reclaiming are the three principal factors involved. The two former must be studied with respect to plant facilities. Reclaiming or oil purification, however, should not be entirely contingent on local conditions, for the type of oil and nature of the chips must also be considered.

The first step in this process involves the manner in which the chips and cuttings are taken from the machine and passed to oil separators. Here practically all the oil which has come in contact with the chips and finished parts is removed and piped to the storage tanks.

Where one or more grades of cutting fluid are used, the chips and parts produced by



Courtesy of Bryant Chucking Grinder Company

Fig. 2—The No. 24 Bryant grinder as designed for hydraulic operation. The cutting fluid used on this machine depends upon the material being ground.

the different oils should be handled separately, extreme care being exercised to prevent mixing of stocks. All reserve tanks should be located so that the temperature of the contents can never approach sub-zero temperatures during the

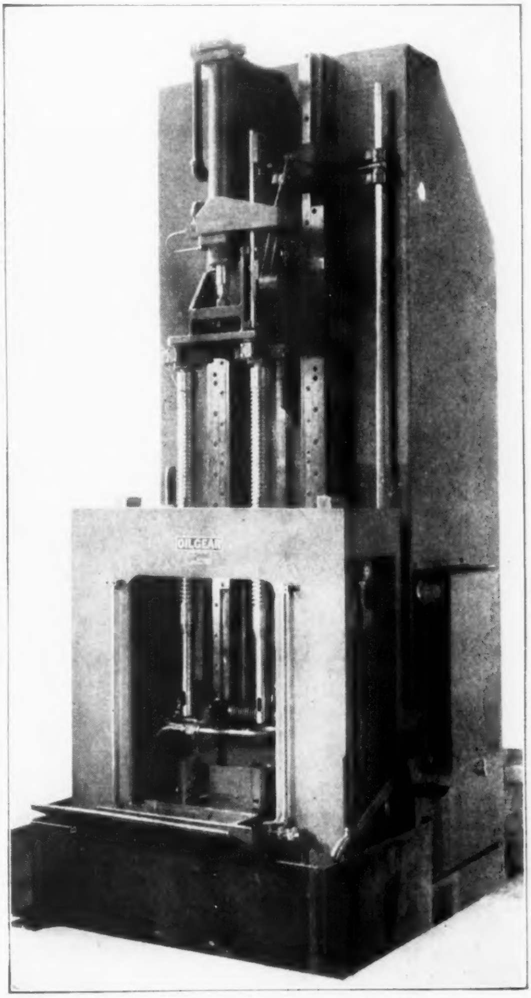
winter months. Any petroleum product will become more viscous when subjected to low temperatures; under such conditions draining or pumping of the cutting fluid from a cold tank will take longer than were the tank to be located in a warm room, furthermore, the oil will not mix as readily with make-up stock. Another point to be considered in the storage of cutting fluids is that if they become congealed there may be possibility of separation of the ingredients which have been added to the mineral base to improve cutting quality. In some cases these ingredients will not go back into perfect mixture when the oil is brought back to normal temperature, and only by prolonged heating and stirring can a uniform product again be obtained. It is, therefore, obvious that proper handling and storage of cutting fluids can lead to marked economy through the use of such products in their intended state, thereby reducing those seasonal epidemics of tool failures which are often so costly.

Reconditioning

To maintain this intended state, adequate means must, of course, be provided for reconditioning or reclamation. As is possible with many other grades of oil, metal cutting fluids can be readily purified or filtered after they have become contaminated in service. This is a very important feature in the machine shop or tool room for regardless of the precautions observed in selecting such products, unless these are maintained in a suitable state of purity and free from abrasive foreign matter, the extent to which satisfactory cutting can be attained may suffer materially. It is rarely considered good practice to discard cutting tool lubricants and coolants until they have been used for some time. Re-usage is practically an economic necessity and can be accomplished readily. The perforated plate or wire mesh which is usually installed in the base of the machine effectively removes most of the larger chips. Later, to finish the job of reconditioning more elaborate equipment is necessary.

Reconditioning equipment may involve a centrifugal chip extractor and oil purifier, or a chip settling tank with a suitable oil filter. In the operation of any such system the oil may be delivered from the machines by hand or truck, etc., and treated periodically, or suitable piping can be installed to enable continuous purification. Both methods have their advantages, and the installation of either will usually depend entirely upon the amount of cutting oil involved, the relative location of the machines, and the rate at which the oil becomes contaminated. Centrifuging is claimed to be distinctive for its ability to remove bacterial impurities.

In planning the installation of a cutting oil reconditioning system, one must first consider the number and location of the machines which

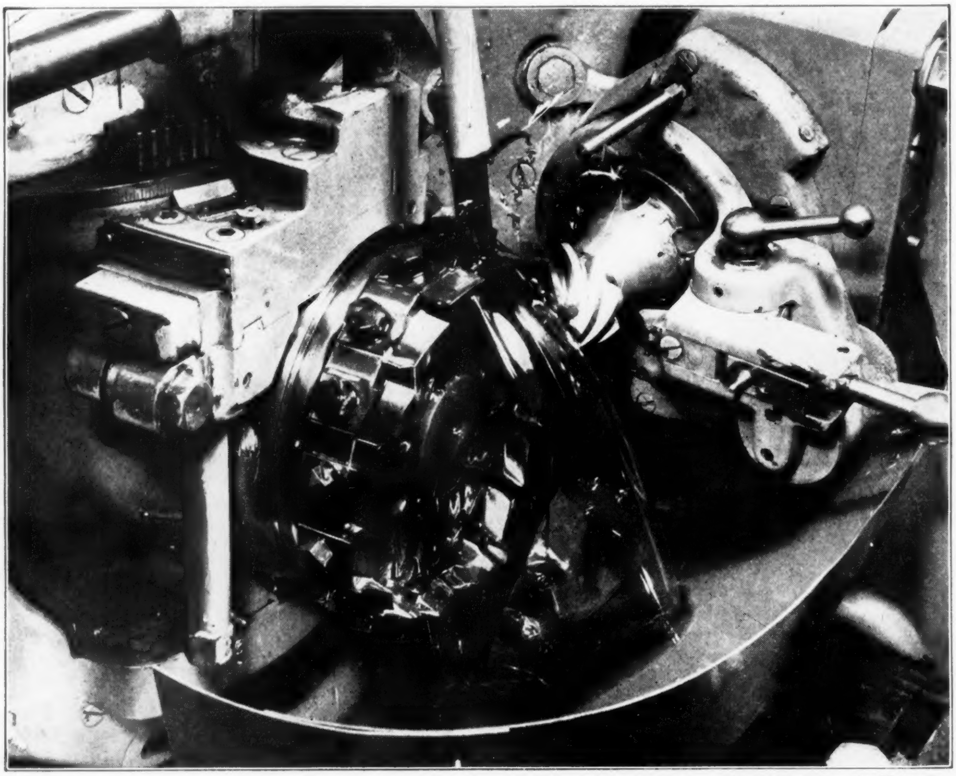


Courtesy of The Oil Gear Company

Fig. 3—The Oilgear Cyclematic Broaching Machine is designed for positive and continuous lubrication of the broaches. As the work passes upward the void between each two broach teeth fills with cutting lubricant flooding the upper surface of the work. Pressure created by the incoming chips forces this lubricant about the cutting edges.

are to be served. For example where the shop is arranged in units it will often be most economical to use a small central reclaiming system for each unit or set of machines. In many cases such installations, while oftentimes numerous, will eliminate the necessity for extensive piping layouts and bulky storage tanks. Furthermore, smaller and less expensive filters or purifiers can generally be used to good advantage. On the other hand, whether or not a purifier for each machine may be necessary will depend upon the size of the latter, its speed of operation, and the volume of oil that must pass to its cutting elements per minute.

The design and construction of the modern machine tool provides for drainage of cutting fluids to a sump or reservoir in the base. Here a metallic filter of varying fineness is usually installed so that the oil must pass through it during the course of drainage. This removes a considerable portion of the larger chips, thereby reducing the work of the reclaimer to a marked extent. But these chips will practically always retain an appreciable amount of oil. They should, therefore, be taken to a settling tank or centrifugal chip extractor which will reclaim this oil and render it adaptable to further treatment in the filter or purifier.



Courtesy of Pontiac Motor Co.

Fig. 4—Close-up of the business end of a Gleason Gear cutter. The rotating cutting wheel is in the foreground, while the spiral bevelled drive pinion which is being generated is in the background. What looks like a cellophane covering is the flow of oil which continuously immerses both the cutter and gear during the generating process.

The general arrangement of any cutting oil reconditioning system, and the equipment to use will depend, of course, upon the nature of the oil involved, and the metal being cut. Softer materials, or methods of cutting which may give a relatively short chip, will often require more oil reclaiming equipment, than where oil from larger, more continuous chips is to be reconditioned. In some cases an extractor or chip basket will serve to purify the oil sufficiently. In others, filtration through the medium installed in the base of the machine will suffice. Then again, some oils may carry such a high percentage of relatively fine abrasive foreign matter that an extensive purifying system may be necessary.

Advantages of Reconditioning

Most machine tool operators are probably influenced chiefly in favor of reconditioning by reason of the fact that the current oil bill can often be markedly reduced, with but a relatively small increase in the cost of plant equipment. There are other distinct advantages, however, which should not be overlooked, viz.:

Cutting tools receive maximum protection due to the fact that the oil is kept free of chips, scale and dirt, which would not only tend to dull the cutting edges but would also lead to increased power consumption.

Considerable time is, therefore, saved because tools do not require as frequent sharpening, thus promoting more continuous production.

The possibility of increase in speed also promotes increased production with usually the possibility for greater accuracy in cutting.

Oil temperatures are reduced with the result that not only the cooling, but also the

lubricating value of the oil is enhanced. Furthermore, by maintaining a cutting oil at lower temperatures the tendency towards oxidation, development of acidity, and the possibility of gumming, are reduced. Acidity and oxidation are regarded by many authorities as decidedly detrimental due to the fact that corrosion and pitting of both the tool and work may be promoted.

Therefore, a higher grade of oil can be used which will give satisfactory service over an extended period of time with but little danger of foaming, etc. This affords far better lubrication of the tools, and wearing parts where the oil is used throughout the machine. All this compensates for perhaps a slight increase in first cost.

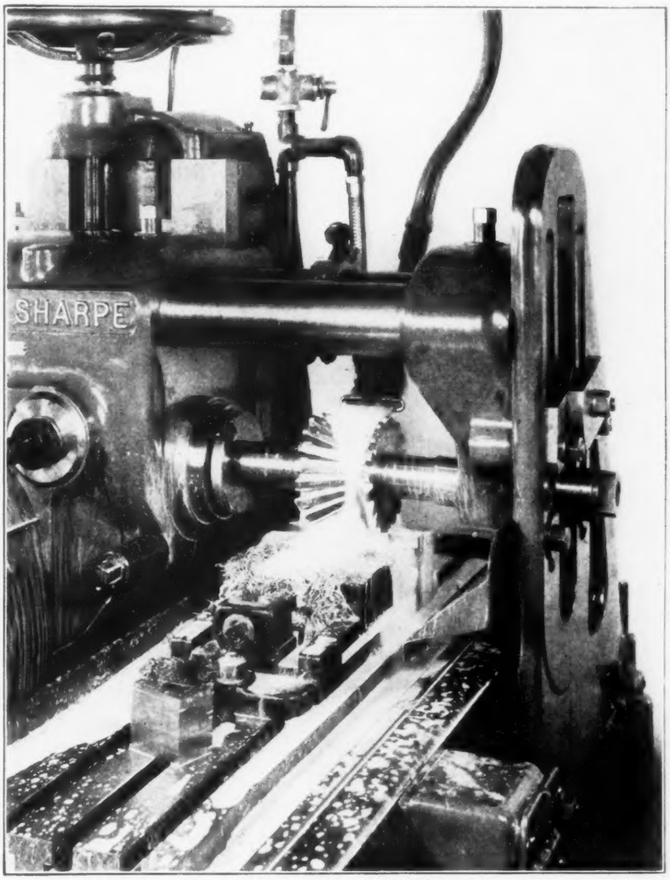
Considerable labor is also saved by such a system for the old familiar method of carrying oil to and from each machine or tank is usually done away with. Furthermore, considerable waste is saved because in most cases the oil is pumped continuously through the system, and manual filling or emptying of oil tanks is eliminated.

General cleanliness around the shop is promoted, for the modern reclaiming system eliminates drips and spilled oil to a large extent.

PREVENTION OF INFECTION

In the handling of cutting oils it is important to remember that a certain potential hazard will frequently exist to materially affect the worker. In other words, certain types of oils, especially those which contain fatty ingredients, will have a tendency to become bacteria-infected and develop into carriers of disease. Every effort should, therefore, be taken not only to select and use oils which will be as non-irritating as possible, but also the operators should observe personal cleanliness very carefully and guard against skin abrasions. This may occur on any part of the hands or arms by wiping with a cloth or rag while the hands or arms are coated with a film of fluid in which metallic particles are suspended. Injury to the skin allows germs to enter, which may cause septic infection. Careful washing and scrubbing of the hands and arms, etc., is claimed by many to be one of the most effective preventatives against infection, by removing ingrained dirt from the pores before it dries. This is especially important in cold weather.

Rancidity of lard oil, the development of free fatty acids, the presence of finely divided metallic particles, poor refinement of the mineral oil constituent, or the presence of certain of the chemicals used in refining have, in the past, been regarded as being the most prevalent causes of skin irritation. Therefore, it is advisable to look into these matters when selecting such oils. Bacterial growth may be accelerated also when the cutting fluid is permitted to become contaminated by organic impurities, such as food refuse. Also, certain types of water used in soluble oil mixtures cause bacterial growth, particularly a water high in magnesium sulfate. Considerable research in this connection has been carried out and certain very helpful data and advice published on the subject. Apparently the most

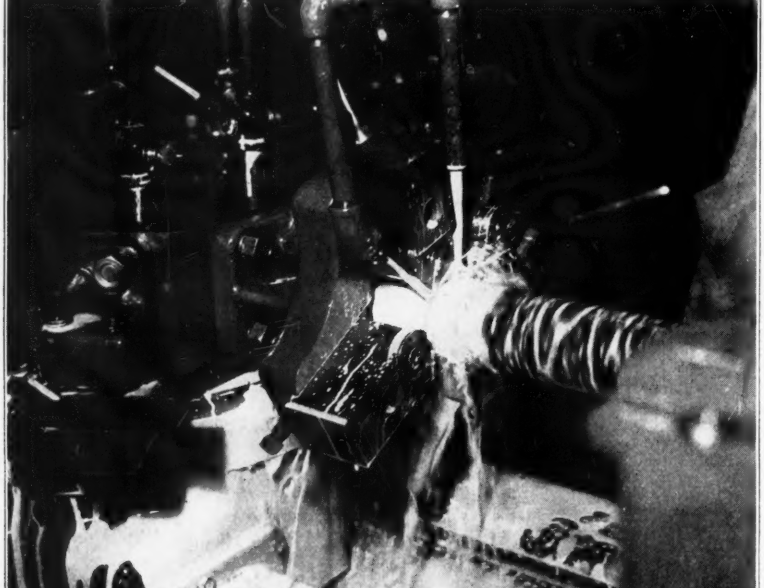


Courtesy of Brown & Sharpe Mfg. Co.

Fig. 5—Milling vernier jaws in a plain milling machine using a special formed cutter. Note manner in which cutting fluid is directed to flood the work.

feasible ways of counter-acting the development of skin infections are:

(a) Personal cleanliness among the operators, and a generous use of soap and a scrubbing brush when washing up.



Courtesy of Jones & Lamson Machine Co.

Fig. 6—A 2½ by 40 Jones & Lamson Universal Saddle type turret lathe turning ½ inch of metal off S.A.E. 120 bar stock. Here again note flood of coolant, likewise its cleanliness.

(b) Careful purification and filtration of the oils to remove contaminating foreign matter, and

(c) The addition of certain disinfectants to the oil to reduce the germ content.

On the other hand, infection among machine operators is not always due solely to the presence of bacteria in the oil. There are other contributing causes, such as poor physical condition of the operator and the tendency of the oil to dissolve fats from the skin to leave it dry and liable to crack or chap.

The germs which cause infection may be on the skin of the workmen or they may have been introduced into the oil. These bacteria are found in air, soil, water—in fact almost everywhere. They ordinarily do not harm because they cannot penetrate healthy skin, but when the skin has become inflamed or the surface scratched or broken, they have a chance to cause trouble. Cutting oils and compounds are often blamed for almost every kind of skin infection which occurs among machinists using them. It is often found, however, that more frequently the germs responsible for the conditions come from sources other than the oil, for investigation has shown that very few well refined mineral oils will contain irritating ingredients; authorities contend they can be kept in the desired condition by centrifuging during service.

Cleanliness of Shop Personnel

Close attention to personal cleanliness and hygiene are the best means of avoiding skin trouble. By frequent and thorough cleansing of the hands and arms with soap, brush and hot water, accumulations of oil and dirt in the skin pores can be prevented. Ether soap, or one containing pine oil, have been found useful in preventing inflammation of the hair follicles. Dusting the arms with a powder containing equal parts of starch and zinc oxide before commencing work protects the skin against irritation.

The U. S. Public Health Service reports that excellent results have been obtained where the men have observed the following precautions:

1. Before beginning work, change from street clothes to shop clothes and put on apron of closely woven cloth, leather, or other substance which will shed oil.
2. Before beginning work in the morning and after lunch, as well as at the close of work at noon and at night, wash with warm water and liquid green soap. If difficulty is experienced in removing oil and dirt from the arms and hands, wash with a mixture of green soap and sawdust, the latter being used instead of a brush.
3. Follow this by rubbing in thoroughly on the exposed parts a little lanoline.

The National Safety Council further advocates that workmen should put on clean working clothes at least once a week, meanwhile, keeping them as clean as possible. They should be particularly careful to prevent the clothing from being soaked with the cutting mixture.

Splash guards attached to cutting machines, gloves and oil-cloth armlets, have been found quite effective in affording protection from fly-

ing chips. Such guards, however, should be made of oil-proof material and should not be allowed to become dirty, loose or ragged.

Spitting into drains or oil pans should be absolutely prohibited, as discharges from the mouth and throat practically always contain bacteria which will contaminate the oil. Cuspidors should be supplied to the machine operators and some provision made for cleaning them daily.

Certain individuals are much more susceptible to skin troubles than others, just as some people are addicted to hay-fever during certain seasons of the year. If possible, such persons should be transferred to other employment.

Cleanliness of Machines

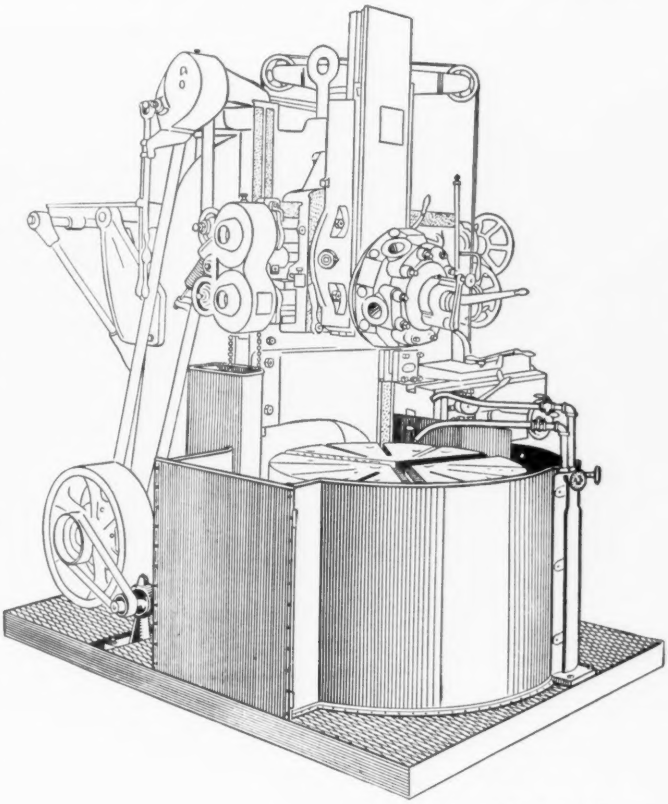
Each machine on which cutting fluids are used should be cleaned frequently, at least once a week, and all sediment and deposits of old lubricant removed.

Purity of Products

Constant removal of the metallic particles is necessary to avoid injury to the skin. Ordinary filtration and centrifuging machines are not always capable of removing the minute metallic particles which may injure the skin. Where straight cutting oils are used, heating will reduce the viscosity sufficiently to permit the metal to sink to the bottom of the tank or container. In the case of soluble oils and sulfur cutting oils, it is necessary, however, to resort to other means for this removal. Usually high speed centrifuges will remove particles even as small as 0.04 mm. in diameter from the compound heated to 150 degrees Fahr.

Various antiseptics have also been added to cutting compounds to prevent rashes, the most popular being carbolic acid, 2% being added to straight oils and 0.5% of a disinfectant soluble in water in the case of emulsions. The results obtained by the use of ordinary antiseptics have not been altogether satisfactory. Reliance cannot be placed upon them unless careful control is exercised over their use by a competent bacteriologist. The use of too much of any such disinfectant is harmful, both to the operator and to the metal.

If disinfectants are used, weekly bacteriological content tests should be made on samples of the oil. When the count exceeds 700,000 colonies of bacteria, the oil is likely to become rancid and employees may become infected. Also it is possible that the metal will show rusting. At such a time the oil should be drained from the system and discarded. It is evident that the initial addition of disinfectants to soluble oils is no assurance that the disinfecting action will continue over any considerable period of use. The effectiveness of the material originally added may be destroyed by dilution and introduction of impurities during its use.



Courtesy of The Bullard Company

Fig. 7—Details of the cutting lubricant system on a Bullard vertical turret lathe.

Sterilization by Heat

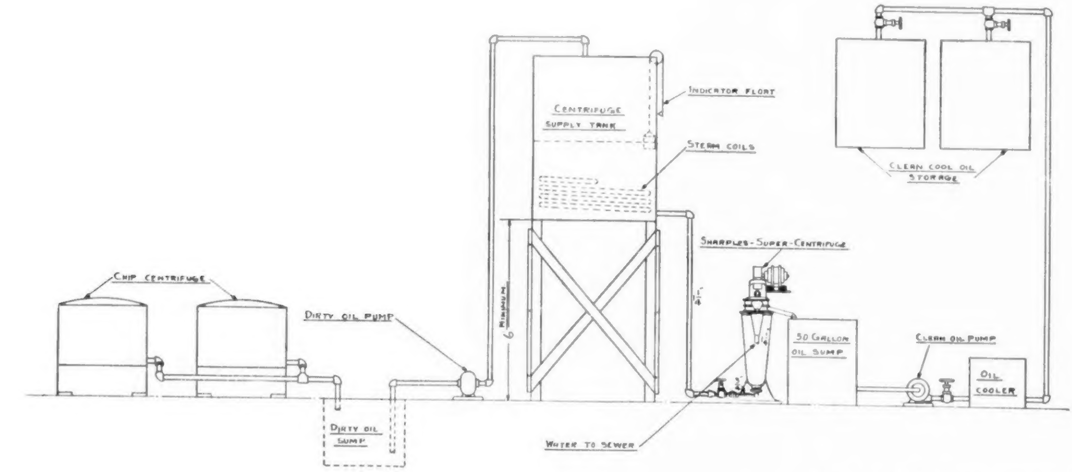
Some of the larger users of cutting oils heat the used cutting fluids for a short period of time to promote sterilization. The temperature required to bring about complete germicidal action is upwards of 245 degrees Fahr., although a lower temperature may be used if tests indicate a sufficient reduction in the bacteria count.

Treatment of Operators

When an operator has contracted a skin infection he should be immediately removed from any possibility of contact with the cutting fluid. This is extremely important where one or more machines are supplied with cutting fluid from the same source, as a single case of skin infection can very easily contaminate the supply of

oil to all machines and cause a skin epidemic not easily brought under control.

Should the cutting fluid be contaminated, it is not sufficient to just discard it; in addition, the reservoir, pipe lines, machines, pumps or infectant. If this precaution is not followed there may be enough of the germs left in the crevices of the equipment to contaminate the fresh supply of cutting fluid in a very short time.

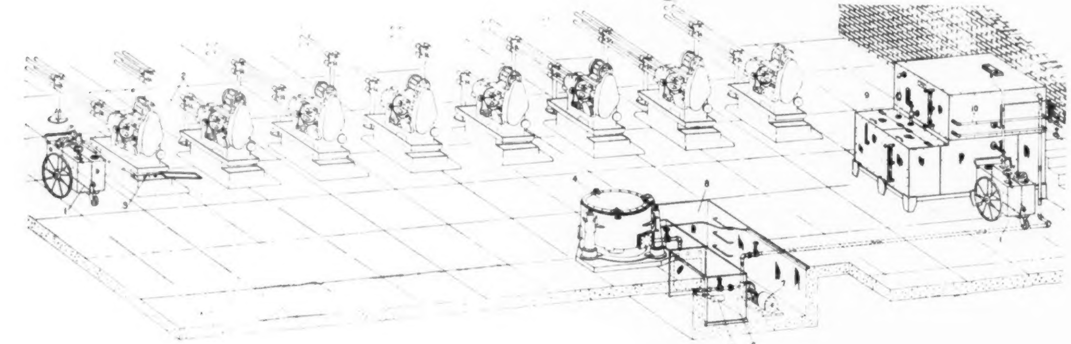


Courtesy of The Sharples Specialty Co.

Fig. 8—Method of installing the Sharples Super-centrifuge in connection with a system for clarification of cutting oil from chips is shown clearly above.

any other equipment used in handling the cutting medium should be cleaned with hot water which has been treated with a strong dis-

From data collected on skin infection, it indicates that cleanliness is the most important factor in preventing it.



Courtesy of S. F. Bowser & Co., Inc.

Fig. 9—One of the Bowser methods of filter installation, for reconditioning of cutting oils.

Parking Made Easier by Snow Removal Machinery

But a few years ago the presence of hillocks of snow and ice on city curbs was an accepted condition of winter in our North Temperate Zones. It was a condition which soon dispelled the thought of "beautiful snow" immediately one had to climb over a three foot pile of jagged ice, or filled his shoes with slush when the thaw came. Something had to be done. The pick and shovel could not suffice with the increasing demands of traffic in congested areas, nor did the tractor and scraper do much better. Frequently the only result was to pile it higher.

Then the engineer came into the picture. If one could load coal and other mineral products mechanically, why not snow and ice. That the machinery designed for underground handling of coal for heating purposes could be adapted to loading and removal of snow and ice, probably never occurred to the designers when confronted with their initial problem. Yet, in the case of at least one type of machine being used today for bulk removal of snow, the principles of the coal loader are outstanding.

It has been an interesting adaption of modern materials handling machinery, this matter of snow removal. Divorced from the predetermined ideas of any of the sponsors, it has demonstrated the flexibility of the mechanisms involved and the originality of the designers. Hand in hand with the latter came the chemist and lubrication specialist, for we had a problem of maintenance of operations under definitely adverse conditions—cold and moisture. The problem of the chemist was to devise lubricants to meet these conditions, with adequate fluidity to prevent binding on cold starting, and assure complete coverage of the contact surfaces of the moving parts. The lubrication engineer had to perfect ways and means, in cooperation with the builders, to keep these lubricants where they belonged to prevent undue loss and eliminate hazard as far as possible. The machinery illustrated herewith is tangible evidence of the success of such a program of teamwork. The problem was diverse for it involved the internal combustion engine, intricate assemblies of gearing, chain elements and a wide variety of bearings.

Power for both propulsion of the machine as well as operation of the escalators or snow conveying mechanisms is developed by the heavy duty gasoline engine. This power is transmitted from the engine clutch either directly to the transmission or through the medium of a flexible coupling. In some designs the transmission is a self-contained unit together with the differential and rear axle. Inasmuch as the power developed must at times, or simultaneously, be applied at two points, viz., the differential and conveyor, two clutches are necessary in connection with the transmission, one for each of the above points, each operating independently of the other.

Engine, transmission and differential lubrication in snow loading machinery is quite similar to lubrication of heavy duty trucks. All builders have designed for maximum protection of their equipment, so the possibility of contamination of lubricants from any external source is remote. This is of considerable importance in snow loader operation where even normal service is severe, and where exposure to the elements may go on for days.

Elsewhere, however, on some types of loaders, parts may not be as well protected. This applied particularly to the roller chains which are widely used for operating the conveyor belts. Normally, such chains, along with their companion sprockets, are entirely exposed. In some machines certain of the gears may also be inadequately protected.

ENGINE LUBRICATING SYSTEMS

Standardization of design in planning for the lubrication of any heavy duty type of engine has given consideration to both circulating force feed and splash oiling.

Circulating systems involve continued usage of the oil in the crank case over the life of the particular oil. The full pressure system of lubrication is preferred by many in view of the fact that a sufficient amount of oil is assured to all moving parts when the engine is running, and no oil is wasted or discarded until its lubricating value has been so reduced as to render this advisable. In this system the oil is forced to the various engine parts to be lubricated under positive pressure by means of a suitable pump (usually of the geared type), which is located in the oil reservoir.

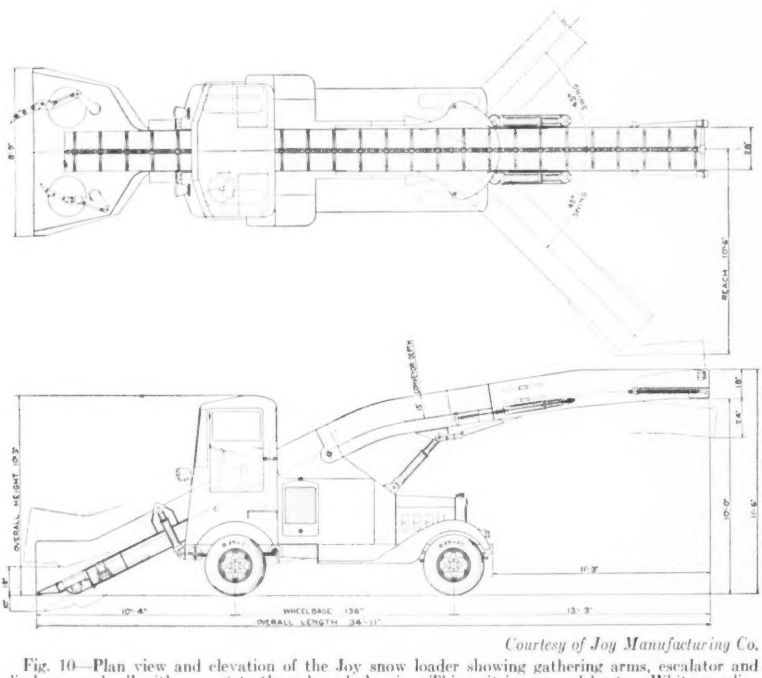
Splash lubrication by oil from the reservoir in the crank case is a somewhat simpler means of bringing about effective lubrication of certain engine parts, the oil circulating back to the reservoir by gravity for reusage.

Operating Conditions

When selecting an oil for any particular type of lubricating system, it is especially essential to know in advance just how the oil will act on starting, and also the degree to which it will lend itself to complete circulation and main-

tenance of a protective film between the wearing elements, when subjected to the bearing pressures developed during actual operation.

It can be appreciated that if the oil is too heavy in body, it may not pump or flow readily throughout the system. There may also be the



Courtesy of Joy Manufacturing Co.

Fig. 10—Plan view and elevation of the Joy snow loader showing gathering arms, escalator and discharge end, all with respect to the cab and chassis. This unit is powered by two White gasoline engines, one driving the gathering mechanism and conveyor, the other furnishing the power for traction.

possibility of congealment within the bearing clearances and on the cylinder walls to cause difficulty in starting.

As a result, both the pour test and the viscosity must be carefully studied at the starting and operating temperatures. Unless the oil has these characteristics to the proper extent, it may be unsatisfactory for the duty involved. Even perfect suitability in either one case or the other does not recommend its usage, for an abnormally high pour test or a viscosity unsuited to the starting temperature may lead to ultimate trouble.

To realize this, it is essential to appreciate that engine lubrication requires the development and maintenance of a suitable film of oil on the cylinder walls and within the clearance spaces of all the bearings at the temperature of operation.

THE TRANSMISSION AND DIFFERENTIAL

Transmission and differential construction in the snow loader is similar to that of the modern motor truck. The purpose of the transmission is to enable the operator, by manipulation of a lever, to select such speed or gear ratios between the engine, the rear axle and snow conveyor as will best meet the road conditions and the depth and nature of the snow.

The differential as applied to the rear axle and snow handling mechanism also involves an arrangement of gears. Its function as a drive is to transmit power and facilitate turning and maneuvering. For this purpose according to the design of the drive, worm, spur or bevel gears are used today. Each is rugged, simple of design, relatively silent and capable of effectively meeting the usual heavy duty involved.

Whatever the type of drive, however, the lubrication of transmission and differential gears in general will involve two distinct problems; first, the lubrication of the gear assembly and second, protection of the shaft bearings.

Inasmuch as the one lubricant must, as a rule, serve both gears and bearings, it must be of sufficient viscosity to not only maintain the requisite film of lubricant on the gear teeth, but must also have adequate penetrative ability to serve the bearings whatever their type or design.

The principal function of a gear lubricant is to provide a cushioning film between the gear teeth, thereby reducing the shock of impact between the teeth and preventing scuffing of the contact surfaces. Any heavy duty transmission and differential must be able to withstand the severe operating conditions which usually prevail, without attention, for considerable periods of time. For this reason all such parts as shafts, bearings and gears are made extra large, thereby safeguarding these units against possible overload and excessive gear tooth pressure,—factors which would result in abnormal wear and noisy operation. The manufacturers also provide for an unusually large supply of gear lubricant in the transmission and differential to eliminate frequent fillings.

The cost and relative amount of lubricant required for these parts however are comparatively small. On the other hand, the function is extremely important. For this reason most careful attention should be given to the selection of any such product. Absolute protection

of both gears and bearings must be assured to prevent abnormal wear and increased maintenance costs which would be caused by an inferior lubricant.

A good gear lubricant for snow loader use should contain no inorganic fillers such as talc, mica, graphite or asbestos, which would become lapping agents. It should resist separation, be non-abrasive, non-corrosive, have minimum tendency towards oxidation and resist air entrainment and expansion. It also must have good adhesive qualities and must not channel under normally low temperatures.

CHAIN DRIVES

The roller type chain predominates as the secondary medium of power transmission to the various escalator and conveyor mechanisms in the average snow loader. Chains of this type are constructed with considerable care as their normal duty is to function under adverse operating conditions and frequently severe loads. Their exposure to the elements in snow loader service imposes an added detriment to effective lubrication, viz., the probability of penetration of abrasive foreign matter. Furthermore, the lubricant must be able to resist the washing action of water.

For this reason the bearing or contact elements which compose the average roller chain are carefully machined to a smooth finish, and designed to fit with comparatively close clearances. This will preclude abnormal wear by facilitating maintenance of a suitable lubricating film under any but the most extreme conditions, as has been experienced with motor truck chain drives. The lubricant, however, must be suited to the operating conditions, the temperature range, and sufficiently adhesive, yet penetrating, to resist throwing off by centrifugal force.

To partially meet this latter requirement careful consideration must be given to the viscosity. In the realization that the snow loader must operate at reduced temperatures, frequently in the neighborhood of zero Fahrenheit, the fluidity of any chain lubricant should always be considered under such conditions. It is not enough to select a product comparable to a steam cylinder oil at room temperatures; for there must still be adequate pliability at zero, and yet the product should never become so fluid on a warm day as to drip to any excess. All this, therefore, requires consideration of the method of refinement of the lubricant for thereby is the relative viscosity determined along with the adhesive properties. Straight mineral oils having a viscosity range around 100 seconds Saybolt Universal at 210 degrees Fahr., or in other words, within the S.A.E. 90 range, are normally adapted to such conditions.

The pour test is also important. This test is a measure of the ability of a lubricant to flow at low temperatures. When considered in conjunction with the viscosity it can be taken as a guide to the extent to which the lubricant will follow the chain and sprocket elements at low temperatures. Unless the pour test temperature is sufficiently below the average operating temperature, some types of lubricants or blended gear compounds may congeal or solidify to such a degree as to crack and drop off from the chains, leaving the surfaces exposed to the possibility of rust, corrosion and abnormal wear.

EXTERNAL OR CHASSIS LUBRICATION

The various so-called chassis parts on the snow loader, viz., those parts designed for grease lubrication by means of the pressure gun, will include a variety of plain or anti-friction bearings as applied to the conveyor mechanism and snow gathering device, the steering gear, axles, wheels, universals and spring shackle bolts. All these parts are more or less exposed to the elements and not always entirely protected against entry of water or abrasive dirt. One must, therefore, depend on the lubricant to assist in such protection. This it does by forming a seal around the parts.

A grease for such service must, therefore, possess good adhesive qualities, be able to resist wheel wash, have a high degree of lubricating value, and never become so hard when exposed to cold as to bind the parts or drop off. It should, furthermore, be as free as possible from acid-forming tendencies to assure protection of the intricate surfaces of the wheel bearings, steering connections, grease-lubricated universals and shackle bolts. This calls for a grease of practically neutral reaction and one, which is free from fillers or any material which may accelerate oxidation, decomposition, or the development of free acidity. In preparing such a grease the most careful attention is paid, therefore, to the character and purity of the soap content, and to the viscosity of the lubricating oil used inasmuch as this oil must do the actual work of lubrication.

This has led to the development of a distinctive type of lubricant which possesses very marked advantages over the so-called cup grease; it is soft, pliable and plastic, and yet has decided non-fluid tendencies. Furthermore, it is able to form and maintain its own housing and capable of "training" or adhering both to wearing surfaces as well as itself, in much the same way that bread dough adheres and yet "strings out." It is also resistant to

heat and to centrifugal force, and yet it has no tendency to separate or break up even under the hardest kind of rough treatment. It is equally capable of lubricating the steering gear, the roller bearings of front and rear wheels, or the mechanisms of a universal joint.

It can be applied by means of pressure lubricators or by hand. It does not drip or flow under high temperatures, and it contains an oil of maximum lubricating ability, with the result that it is economical and capable of giving service for extended periods of operation.

HYDRAULIC POWER

Regulation and adjustment of conveyor or escalator mechanisms is widely accomplished by use of oil hydraulic power. The purpose in view has been to adopt a means of power transmission which will enable maximum flexibility with regard to discharge, and accurate adjustment to conform to irregularities in street surfaces. This involves a pump or so-called fluid motor, operating at a pressure proportional to the amount of fluid to be delivered. Straight mineral oil of comparatively light viscosity is used in this device; it is, therefore, capable of serving a dual purpose—as the working fluid and as a lubricant for the interior mechanisms.

The latter is facilitated by allowing for a certain amount of leakage of oil. According to the design, this leakage takes place between the face of the cylinder barrel and face of the valve-plate, or past the plungers. Inasmuch as the oil is under considerable pressure, whenever the mechanisms are functioning, there is assurance of a sufficient film of oil between all working surfaces of the pistons, plungers, cylinder barrel and valve unit provided the oil temperature is not allowed to rise much above normal.

Leakage of oil or working fluid, of course, results in a certain reduction in effective displacement of the pump. There is normally no loss of oil, however, even though there is leakage within the mechanisms, for that oil which serves to lubricate is drained back to a suitable reservoir located in the unit.

Freedom from Air Essential

An hydraulic power transmission system functions at its best when entirely filled with oil and as free as possible from air. For this reason, filling of the system requires considerable care and attention. Those who are familiar with the instructions issued by motor vehicle builders relative to use of hydraulic fluid in hydraulic brakes, know full well of the benefits to be derived from following these instructions.

Air will most usually gain entry at the time of filling the system with oil, unless there may be leakage at some high point in the system, or between the tank and pump. Normally, however, any aperture capable of leaking air will also allow oil to pass out. Entry of air may also be caused by leaky packing.

Entry of air at the time of filling cannot be prevented entirely. It can, however, be materially reduced by adding make-up oil very slowly and where practicable straining through one or two thicknesses of cheesecloth. Subsequent formation of air pockets can be eliminated by locating suitable air relief valves at certain of the high points.

Resistance to Breakdown

In an hydraulic power transmission system there is normally but little opportunity for the oil to rest and separate itself from water emulsions. Under oxidizing conditions sludge formation may, therefore, develop. Sludge is a distinct detriment to lubrication, for it will tend to accumulate in clearance spaces, ports or other small apertures in the pump to interfere with free flow and leakage of the oil past those parts which require a lubricating film. Sludge accumulations in some oils may also be conducive to acidity, which may lead to corrosion.

Lubricating oils of a very high degree of refinement should, therefore, be used in any such mechanism. It is especially important that they be entirely free from abrasive or contaminating foreign matter. High demulsibility, or an ability to separate readily from water, is not always essential, however, unless the system may be subjected to considerable water leakage. On the other hand, low oxidizing and carbon residue forming tendencies are most important characteristics. They will normally be indicative of the durability of the oil and a guide to its resistance to breakdown.

Printed in U. S. A. by
Edgar C. Ruwe Co., Inc.,
72 Washington St., N. Y. C.

LUBRICATION INDEX *for*

VOL. 22, 1936